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New products and corruption: evidence from Indian firms *

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Abstract

It has been shown that corruption has a negative effect on firm productivity, but what about its impact on product innovation? We find that corruption, functioning as a bribe tax, diminishes the probability of new product introduction. We use a World Bank Enterprise Survey from India in 2005, with 1600 firms answering if they introduced a new product to the firm and on the average quantity of bribe paid by firms. Controlling for innovation determinants, firm characteristics, location choice, multi-product firms and other business environment variables, sector-location bribe averages have a negative and significant impact on product innovation.

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Key-words: innovation, corruption, firm performance

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1 Introduction

Nowadays there is a large consensus on the positive effect of innovation on economic growth and development (Aghion and Howitt, 1998; Almeida and Fernandes, 2008; Lederman, 2010), leading to a growing body of economic literature that relates technological diffusion with different levels of economic performance (Goedhuys, Janz, Mairesse, and Mohnen, 2008). Even though an extensive compilation of innovation surveys is available (Mairesse and Mohnen, 2010), there is still lots of room for empirical microeconomic work in developing countries on the subject (Goedhuys and Veugelers, 2008).

We contribute to this literature by examining if corruption blocks product innovation on the firm-level. Fisman and Svensson (2007) find that corruption has a negative effect on Ugandan firm's growth and De Rosa, Gooroochurn, and Gorg (2010) show that firm productivity in Central and Eastern European countries is negatively correlated with corruption. Their studies are supported by the largely developed literature on the detrimental effect of corruption on economic development (Bardhan, 1997). In this paper we study the impact of corruption on product innovation at the firm level by combining the literature on product innovation and on corruption and firm performance. We address this issue empirically, using a World Bank Enterprise Survey dataset on Indian firms in 2005, which to our knowledge has not been used for this country with our purposes.

In that sense, we construct sector-location averages from the firm's manager answers on the percentage of bribes paid relative to annual firm sales. The sector-state level measure deals with endogeneity and measurement erros from the firm's individual response, as Fisman and Svensson (2007). However, we use this variable directly on the regressions, treating them as exogenous at first, following Dollar, Hallward-Driemeier, and Mengistae (2005) and Amin (2009), even though our results do not change when using an instrumental variable approach as Fisman and Svensson (2007). Controlling for a set of innovation determinants and firm characteristics, we use the bribe variable to explain the introduction of new products in a single firm. And why India? At first, there is a large literature on the institutional quality using Indian examples, from the Krueger (1974) seminal paper to recent evidence on how corruption is a major issue for Indian economic growth (Heston and Kumar, 2008). It also gives us a large firm dataset, with around 1600 firms located in several Indian states, so we can capture the difference in sector-state averages to measure corruption. And using only one country can eliminate significant heterogeneity in the bribe's level measurement, which could arise from cross-country regressions and unobserved heterogeneity across countries (Fisman and Svensson, 2007).

In respect to the firm-level literature on product innovation in developing countries, Goedhuys (2007) uses Tanzanian firm data from the World Bank Investment Climate Survey (WBICS) to investigate the effect of various sources of learning, investment and linkages on firm's product innovation. Estimating a probit model with many regressors to explain product innovation, she finds that foreign ownership, size, skills, internet use and collaboration with other firms have a significant impact on the probability of being an innovator. Also employing a WBICS, a similar paper looks at the strategy that leads firms to be innovators. Goedhuys and Veugelers (2008) report that for a large sample of Brazilian firms, the buy strategy, related to the purchase of external technological know-how, is more important for product innovation when compared to the make (internal creation) strategy.

Using WBICS for many countries, Lederman (2010) studies how contextual factors affect firm perfomance, and especially the probability of introducing a new product. He uses a two-stage empirical model to explore different hypothesis that can explain the probability of product innovation, evoking three possibilities: global engagement, information spillovers and market structure. The author finds that size, licensing, export status and R&D are significantly related to the probability to innovate. His results support the global engagement and information spillover hypothesis, but no clear result from the market structure hypothesis can be made. Counter intuitively, the institutional quality has a negative influence on the propensity to innovate, due to the market structure hypothesis where incumbent firms can prevent competitor's entry by requesting special favors from the government. We take his results with caution and different from our perspective, as the author employs a macroeconomic approach[1].

[1] In a similar macroeconomic framework but with a different econometric methodology and database, only one paper tried to test the relationship between innovation and corruption (Anokhin and Schulze, 2009), finding a negative effect of corruption on innovation.

These articles on the determinants of product innovation do not take into account the significant effect of corruption on firm perfomance, as mentioned above[2]. In summary, in this paper we test if corruption hinders the introduction of new products at the firm level. The mechanism could happen in many ways: as explained by De Rosa, Gooroochurn, and Gorg (2010), if the risk of expropriation is high, innovation investments will be hampered. Innovations could demand for new licenses and permits, opening a space for the capture of corruption by bureaucrats. And a bureaucrat, if rational and profit maximizer, will try to capture a part of the new profits generated by the new products, so they tax these new products through corruption.

At first, we find a significant heterogeneity in product innovation and corruption level throughout Indian states and economic sectors. Empirically, sector-state bribe averages have a negative and significant impact on product innovation. This effect holds for different approaches and many robustness checks, such as the location choice of firms, the size of the sector-state clusters and multi-product firms, for example. We also show that corruption has a negative and significant effet on innovation through a two-stage instrumental variable approach with a probit model in the second stage. For this last test, we follow Fisman and Svensson (2007), where the individual response is instrumented in the first step by the sector-location average and the fitted values are used to explain product innovation. By incorporating the presence of corruption and its negative effect on firm perfomance, we contribute to the product innovation literature on firm-level studies in developing countries. From our results a policy agenda that promote innovation could be drawned, as we show some of the binding constraints on product introduction at the most disaggregated level.

The rest of the paper is organized as follows. In section 2 we present the data, the variables and the departure point for our econometric approach. Our empirical methodology and results are on section 3, and in section 4 we test the sensitivity of the results. Section 5 concludes.

[2]Goedhuys, Janz, and Mohnen (2008) present the Banerjee and Duflo (2005) finding on how firm growth can be affected by burdensome legal procedures settled by the government. They also highlight the Eifert, Gelb, and Ramachandran (2005) results where bad quality business environment diminishes firm productivity in Africa. In their own work, Goedhuys, Janz, and Mohnen (2008) use the same Tanzanian WBICS survey cited above and they find that traditional technological variables, as R&D, have no impact on firm productivity. Differently, business environment have a significant effect on firm productivity.

2 Data

To test if the level of corruption is a binding constraint on product innovation, we use a dataset from the World Bank Enterprise Survey on Indian firms in 2005 consisting of 2280 enterprises, but as complete data for some variables are not available, we have around 1600 firms in most estimations. According to the survey's methodology[3], the sampling provides small, medium and large firms. The questionnaire is conducted by private contractors and the top manager or the business owner of each firm answers the questions. There are important information on each firm such as its sales, capacity, ownership structure, financing, infrastructure and location. Data consists of firms located in 17 different states from all regions of the country, and also from different manufacturing sectors. Information on sectors and states can be found in the appendix.

The main variables are the introduction of new products and the bribe measure. To build our explained variable, the question is if the firm developed an important new product line in the last two years. This binary variable captures innovation (ino) which is defined as an innovation for the firm, but not necessarily for the market[4]. It is also important to note that the product innovation variable is constructed in the same way as the ones used in the innovation articles presented in the introduction. Nonetheless, it is interesting to look at how innovation is defined and how innovation surveys capture this phenomenon, as it is done in similar way in the World Bank Enterprise Surveys. Mairesse and Mohnen (2010) acknowledge the important contributions of the Oslo Manual (OECD, 2005), which defines innovation, its sources, effects and other important characteristics. Mairesse and Mohnen (2010) present some features of the Oslo Manual we highlight: innovation surveys contain (a) indicators of innovation outputs, such as new products, as our explained variable; (b) a range of innovation expenditures, as R&D, product design, personnel training, and others; and (c) information on how innovation proceeds, such as obstacles, reasons and sources of knowledge. The data collected concerning these informations makes it possible the econometric use of different innovation surveys.

From the 2266 firms that answered the innovation question, 1370 said there were no product

[3] All these information is publicly available at the site of the World Bank Enterprise Surveys.

[4] We follow Goedhuys (2007) definition on this phenomenon, where the new product to the firm dimension is the relevant one in developing countries.

innovation, while 896 aswered it positively. Summary statistics for the main variables are in Table 1 below. In the appendix, we see that firms innovate in all states and in most sectors, but with a heterogeneity amongst the proportions. There are some exceptions, such as Tamil Nadu, Uttar Pradesh and Haryana, where there are more innovative firms in comparison with those that do not introduce new products. When looking at firm size (second table at appendix A), we find the usual trend (Goedhuys, 2007) where large firms are more innovative than small firms (category 1).

Our main explanatory variable, the bribe measure, is constructed as the sector-state average of the firm's response. As evoked earlier, we follow Fisman and Svensson (2007) and we also think that grouped averages helps to deal with endogeneity from the individual perception and handles measurement errors. The firm manager answers if "establishments make gifts or informal payments to get things done with regard to customs, licenses, regulation, services etc" and if the answer is positive, "on average, over a year, what percent of annual sales would such expenses cost a typical establishment in your of activity?". This question is similar to the one used by Fisman and Svensson (2007) and at the end we have around 170 different sector-state values for the bribe measure.

In Figure 1 below, we find that the average of bribe is quite heterogenous between Indian states. While in Jharkand, Karnataka and Madhya Pradesh, the average bribe is around 15 percent, other states, such as Haryana, Orissa and Kerala, have an average of 2 percent. Figure 2 shows that the distribution of the bribe measure is not concentrated in a specific region of the country. In Figure 3, the sector with the high level of bribes is paints and varnishes with 18 percent, followed by plastics and plastics products with around 12 percent. The lowest ones have a average bribe of around 1 percent.

The other explanatory and control variables are the determinants of product innovation and firm characteristics, following the literature on the subject (Goedhuys, 2007; Goedhuys and Veugelers, 2008; Lederman, 2010). As our main explanatory variable is measured in the sector-state level, we control for per capita GDP and population size for each state (lpibpc and lpop), coming from the Indian Census in 2001. From the World Bank Enterprise Survey, we control for the age of

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
ino	0.395	0.489	0	1	2266
bribe	7.043	11.473	0	84	2096
license	0.052	0.223	0	1	2180
rd	0.27	0.444	0	1	2272
lage	2.565	0.784	0	4.5	2251
lsize	3.231	1.329	0	8.517	2129
overdraft	0.53	0.499	0	1	2275
training	0.159	0.366	0	1	2146
foreign	0.006	0.078	0	1	2280
internet	0.615	0.487	0	1	2271
neweq	0.431	0.495	0	1	2280
certification	0.225	0.418	0	1	2260
export	0.446	0.497	0	1	2280
highsk	0.787	0.409	0	1	2258
multi_product	0.414	0.493	0	1	2062
profitability	-0.01	2.498	-47.035	1	
lpibpc	9.335	0.423	8.177	10.406	2280
lpop	17.757	0.688	13.711	18.929	2280
a7_high	1.734	0.259	1.072	2.493	2280
a7_trade	0.903	0.257	0.119	1.481	2280
a7_labor	0.987	0.255	0.393	1.616	2280
a7_bizlic	0.687	0.182	0.143	1.192	2280
a7_ecouncer	0.725	0.216	0.136	1.252	2280
a7_crime	0.721	0.209	0.182	1.933	2280
a7_antico	0.51	0.171	0.085	1.165	2280
a7_regspe	0.389	0.163	0.061	1.042	2280
a7_legal	0.44	0.176	0.086	0.99	2280
subcontract	0.103	0.304	0	1	2246
ln_rdint	0.208	1.094	-6.522	10.752	2280
world_compet	0.181	0.385	0	1	2280
pub_funds	0.008	0.089	0	1	2280
domestic	0.036	0.185	0	1	2280

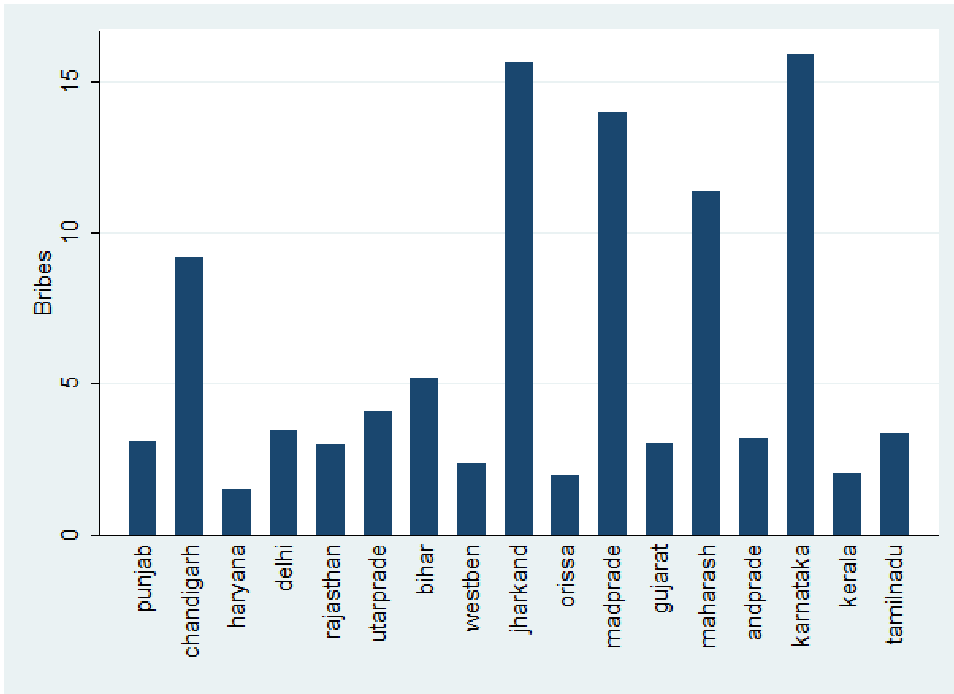

Figure 1: Bribe measure by state

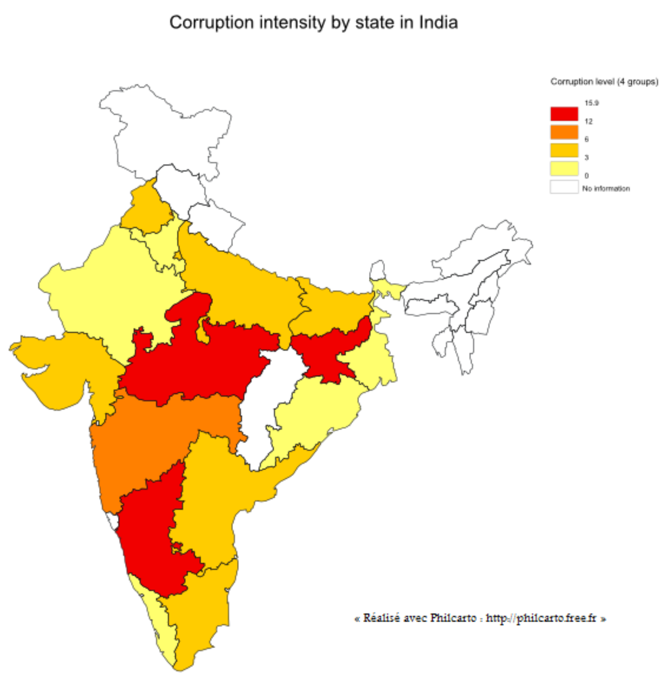

Figure 2: Map of India: Bribe measure by state

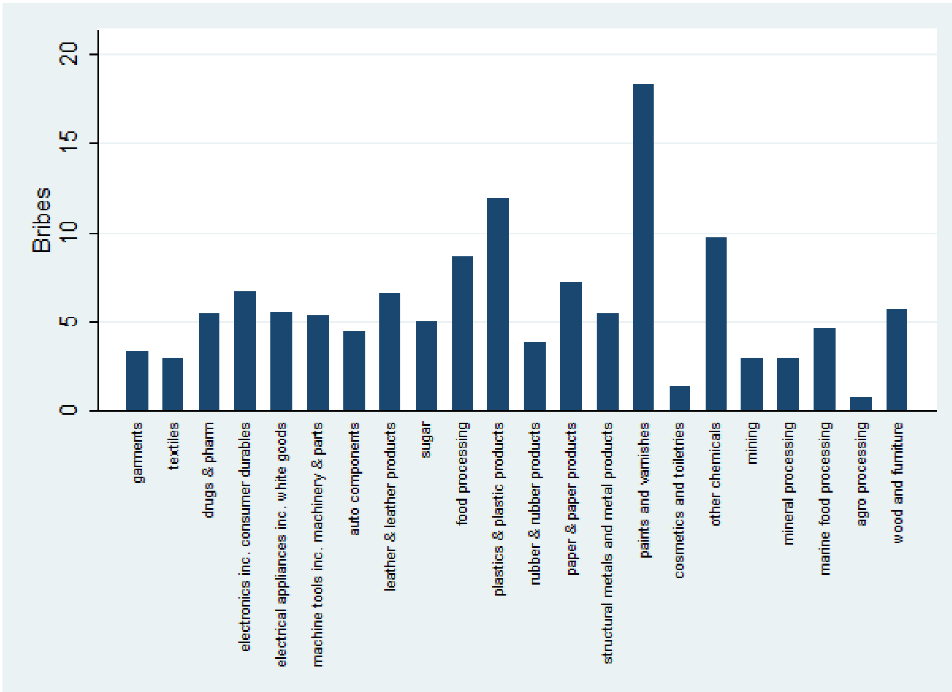

Figure 3: Bribe measure by sector

the firm (lage, in its log form) and its size (lsize), which represents the average total number of workers in 2004.

We control for the use of licensed technology (license) from a foreign owned company, and also if the firm engages in research and development (rd). We construct the external and internal training variable (training) that captures the effect of skill improvement. The education level of the owner or the manager is also controlled for, as we build a dummy variable measuring if he has a post graduate degree (highsk). The presence of foreign participation and the export status in the firm are captured by the foreign and the exporting status variables.

Additionnaly, other variables measure distinctive technological factors. We add an internet variable, capturing website and email interaction with client and suppliers. We control for new equipment and machinery purchase in the precedent years of the survey (neweq) and for internationally recognized quality product certification (certification). We build an overdraft facility factor, a binary credit variable that captures financing constraints. The profitability of the firm (sales minus costs divided by sales) is also included, as it could also have an impact on product innovation.

Concerning the robustness checks, in one specification we control for other institutional obstacles that comes from the many respondent's perception of firm's growth and operations obstacles. The manager answers about the degree of severity of each obstacle to firm growth, and their perceptions to each one of the questions are computed in a likert scale item. For example, there is a question to know if high taxes was an obstacle, or labor regulations, crime and theft, and so on. The likert scale in these questions goes from 0 (no obstacle) to 4 (Very Severe Obstacle), so a higher number means a more severe obstacle. In order to use these variables, we slightly modify Amin (2009) (the author uses only state level averages) methodology and we build sector-state level averages (our a7 variables) from the perceptions of these obstacles at the firm-level. As he explains, "averaging helps filtering out the influence of store characteristics on the index... and is also an advantage because information on factors that may exarcebate the endogeneity problem is also available on the survey and we can use this information to control for these factors".

In the last robustness check we test if the impact of corruption on innovation holds using a structural model of innovation. The CDM is a structural model developed by Crepon, Duguet, and Mairesse (1998) where the decision to invest in R&D and the R&D intensity are estimated conjointly, and then innovation and firm productivity equations are estimated in a sequential way. We follow Raffo, Lhuillery, and Miotti (2008)[5] but we only estimate the first and second step. The variables definition for this approach can be found in the appendix.

3 Empirical strategy and results

To estimate the impact of corruption on product introduction at the firm level, we follow the literature on innovation and development (Goedhuys, 2007; Lederman, 2010) and we model innovation

[5]Raffo, Lhuillery, and Miotti (2008) summarize articles using the CDM model on innovation and firm performance. In their own paper they compare European and Latin American countries and through probit estimations on the determinants of product innovation they find that R&D and firm size have a positive and significant effect on product innovation, and that this innovation output has a significant and positive impact on firm productivity. Their results are similar to those of Griffith, Huergo, Mairesse, and Peters (2006) (where they use the same version of the CDM model) for a set of european countries.

as a probit model. We estimate equation (1) below:

$$PRODINNOV_i^* = \alpha_0 + \beta BRIBE_{s,s} + \alpha_1 GDPPC_s + \alpha_2 POP_s + \alpha_3 FC_i + \epsilon_i \quad (1)$$

$$PRODINNOV_i = 1 \, if \; PRODINNOV_i^* > 0; PRODINNOV_i = 0 \, if \; PRODINNOV_i^* \leq 0.$$

Where PRODINNOV is the introduction of a new product in the firm level i. Our explanatory variable of interest is the bribe state-sector (s,s) average. We control for per capita GDP and state population, and we include a set of controls FC, composed by product innovation determinants and firm characteristics explained above. As some of our explanatory variables are in the state-sector level and our Y variable is at the firm level, we cluster our standard errors (as Amin (2009), to correct for the Moulton (1990) effect) in the sector-state level.

Hence, we test if corruption blocks the introduction of new products at the firm level. Dejardin (2011) presents the mechanism developed by Murphy, Shleifer, and Vishny (1993), where innovation characteristics demands many government regulations and licenses, opening the scope for public rent-seeking in the shape of corruption. In order to test this, we add our explanatory variable corruption directly in our regression. We believe that the sector-state measure is exogenous, following Dollar, Hallward-Driemeier, and Mengistae (2005) and Amin (2009), but in the robustness section we show that our results hold when using an instrumental variable approach as Fisman and Svensson (2007).

In Table (2) we show the marginal effects of the regression. In column (1) we use only firm level controls, while in column (2) we add state variables also as explanatory variables. In all specifications bribe has a negative and significant effect on innovation. According to column (2) in Table (2), an infinitesimal change in the level of bribe translates into a 0.56 % higher probability of product innovation. Our results give support to the idea where corruption diminishes the probability of new product introduction.

Concerning our control variables, most of them have the expected coefficient sign in Table (2). The R&D, training and internet variables have a positive and significant effect on the probability to innovate. These results show the important role of these traditional innovation determinants.

Table 2: Probit

VARIABLES	(1) dprobit	(2) dprobit	(3) dprobit	(4) dprobit	(5) dprobit
bribe	-0.00591***	-0.00564***	-0.00550***	-0.00545***	-0.00577***
	(0.00168)	(0.00157)	(0.00168)	(0.00147)	(0.00153)
n					-0.00127
					(0.00127)
license	0.0517	0.0516	0.0981	0.0353	0.0523
	(0.0658)	(0.0678)	(0.0719)	(0.0721)	(0.0689)
rd	0.155***	0.157***	0.152***	0.179***	0.158***
	(0.0369)	(0.0372)	(0.0421)	(0.0370)	(0.0364)
lage	-0.00723	-0.00439	-0.0127	0.000550	-0.00680
	(0.0175)	(0.0175)	(0.0181)	(0.0193)	(0.0179)
lsize	-0.0786	-0.0778	-0.0978*	-0.0892*	-0.0775
	(0.0527)	(0.0530)	(0.0584)	(0.0515)	(0.0519)
lsize2	0.00917	0.00898	0.0102	0.00954	0.00901
	(0.00618)	(0.00621)	(0.00672)	(0.00600)	(0.00610)
overdraft	0.0355	0.0544*	0.0446	0.0513	0.0499*
	(0.0293)	(0.0297)	(0.0337)	(0.0329)	(0.0290)
training	0.0879***	0.0740**	0.0665*	0.0650*	0.0743**
	(0.0333)	(0.0331)	(0.0352)	(0.0370)	(0.0334)
foreign	0.161	0.146	0.0535	0.139	0.133
	(0.174)	(0.171)	(0.179)	(0.171)	(0.172)
internet	0.188***	0.197***	0.222***	0.194***	0.197***
	(0.0297)	(0.0292)	(0.0318)	(0.0316)	(0.0297)
neweq	0.0535	0.0374	0.0253	0.0429	0.0366
	(0.0376)	(0.0379)	(0.0446)	(0.0355)	(0.0378)
certification	0.0562	0.0562	0.0674	0.0745*	0.0551
	(0.0371)	(0.0389)	(0.0455)	(0.0406)	(0.0392)
export	0.0326	0.0393	0.0473	0.0593*	0.0452
	(0.0356)	(0.0350)	(0.0413)	(0.0357)	(0.0367)
highsk	-0.0190	-0.0234	0.000180	-0.0436	-0.0300
	(0.0409)	(0.0418)	(0.0470)	(0.0415)	(0.0400)
profitability	-0.00232	-0.00134	0.000345	0.000635	-0.000925
	(0.00549)	(0.00578)	(0.00653)	(0.00568)	(0.00579)
lpibpc		-0.113**	-0.0789	-0.151***	-0.122***
		(0.0484)	(0.0535)	(0.0413)	(0.0425)
lpop		0.0275	0.0388	-0.00655	0.0255
		(0.0304)	(0.0339)	(0.0240)	(0.0271)
Observations	1,601	1,601	1,278	1,454	1,601
Pseudo R2	0.0972	0.107	0.111	0.110	0.108

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Robust standard errors clustered in the state-sector level are in parentheses.

It appears that having a license, foreign participation, new equipments, certification and export status are positively but not significantly correlated with product innovation. Overdraft facilities have a positive effect, but only marginally significant. The age of the firm has a negative but not significantly coefficient, while the size of the firm appears to have a quadratic correlation, where small and large firms would innovate more, whereas middle size firms have a lower probability of product innovation, although the coefficients are not significant. The education level of the manager and the profitability of the firm have in most part a negative but not significant coefficient. The state GDP is negatively and significantly correlated with new products and it could be explained from the discovery and development framework (Klinger and Lederman, 2006), while the state population has a positive but not significant effect.

In columns (3) to (5) we control for the size of our sector-state clusters. One could say that the results would be biased, mainly driven by clusters that have a smaller or a higher number of observations in our database. Concerning this effect, in column (3) we estimate our regression using only those sector-state clusters who have at least 10 observations, and in column (4) we estimate only with those having less than 50 observations. In column (5) we introduce the variable n which measures the number of observations in each cluster. In all specifications our results remain the same, and it appears that there is no such effect. Another size effect could exist if sector-state clusters with a higher bribe level would be those with mainly small firms. In that case, as the question in the survey asks the percentage of firm sales spent in bribes, this value would be fixed for all firms, and therefore the percentage of sales would vary through different firms. Interestingly, we do not find correlation between firm size and the level of bribe[6].

4 Robustness checks

In our first robustness check we estimate specification (2) of Table (2) with additional institutional obstacles to the firm. In Table (3) we show only these variables and our variable of interest (bribe). The main results do not change, and the coefficient of our bribe variable turns out bigger. The only significant institutional variable is customs and trade regulations, which has a surprising

[6] Results can be obtained with a request to the author.

positive sign[7].

Table 3: Robustness check as Amin (2009)

VARIABLES	(1) dprobit
bribe	-0.00640***
	(0.00177)
a7 high	-0.147
	(0.140)
a7 trade	0.380**
	(0.176)
a7 labor	-0.0439
	(0.118)
a7 bizlic	0.252
	(0.274)
a7 ecouncer	-0.271
	(0.280)
a7 crime	-0.153
	(0.152)
a7 antico	0.0136
	(0.232)
a7 regspe	0.0889
	(0.233)
a7 legal	0.0131
	(0.188)
Observations	1,601
Pseudo R2	0.117

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Robust standard errors clustered in the state-sector level are in parentheses.

Nevertheless, our empirical methodology has some limitations. The first one is that we do not have panel data, so we cannot capture the within variation neither control for firm fixed effects. By controlling for most of the product innovation determinants and firm characteristics, we should capture most part of these effects. Following Amin (2009), we do not think that our estimations suffer from reverse causality, as the main explicative variable is built in the state-sector level.

Next, concerning endogeneity from an omitted variable bias, the bias normally would work in our direction. According to Fisman and Svensson (2007) and the mechanisms describe in the introduction, we think of a rational and maximizing bureaucrat that tries to capture the biggest possible rent. There would be a positive correlation between the bribe level and firm unobservable

[7]Although it could be explained with the Porter regulation framework (Porter and van der Linde, 1995).

features that determine innovation, as the bureaucrat would try to capture a part of the extra profits from the new product. Consequently, the negative effect of corruption on innovation would be underestimated. So if our measure of bribe is capturing the effect of omitted variables that positively determines innovation, then our coefficients would be underestimated[8]. For this identifying strategy to work, the sector-state average used as an instrument would only capture the exogenous part of the corruption individual value. Furthermore, the omitted variables should not be correlated with the control variables.

To give more support to our results, we instrument the individual bribe value as Fisman and Svensson (2007), as this strategy also helps to deal with measurement errors in the corruption data. In the first stage they instrument the response from each firm by the sector-location average constructed as described above, and then they use the predicted value to explain firm growth. We follow Fisman and Svensson (2007) and explain product innovation by fitted values from the first stage regression. In column (1) of Table (4) the sector-state bribe average positively and significantly determines the individual corruption value. At the second stage of the same estimation, in column (2), corruption has a negative and significant impact on product innovation[9]. The evidence from the instrumental variable probit estimation gives support to the negative effect of corruption on product innovation at the firm level, conditional on the exogeneity assumptions and the identification strategy.

In column (3), we try to see if the effect of corruption on product innovation is robust to the introduction of a multi-product dummy variable. It could be that multi-product firms introduce new products more often, producing a omitted variable bias. When controlling for this variable our results do not change, while the multi-product binary variable is positive but not significant. Next, we test the robustness of our results to the introduction of firm characteristics and innovation determinants on the sector-state level, as one could argue that we should try to capture all possible omitted variables at the same level as our main explanatory variable. In column (4) all variables from the overdraft downwards are sector-state averages, and our main results are robust to this

[8]And it is difficult to think of omitted variables that could lead to a negative bias in our regressions. More on the discussion between bribe and omitted variables, see Fisman and Svensson (2007)

[9]When we calculate the marginal effect on tip from column (4), we find a higher coefficient (-0.04) than column (2) from table 2 (-0.005).

Table 4: Instrumental Variable Probit and other robustness checks

	(1)	(2)	(3)	(4)
VARIABLES	IV-tip	IV-inno	dprobit	dprobit
bribe	0.106**		-0.00560***	-0.00531***
	(0.0497)		(0.00159)	(0.00146)
tip		-0.113***		
		(0.0415)		
license	-0.211	0.0839	0.0452	0.0752
	(0.289)	(0.150)	(0.0674)	(0.0608)
rd	0.552	0.390***	0.157***	0.193***
	(0.383)	(0.0953)	(0.0382)	(0.0368)
lage	-0.0983	-0.0202	-0.00278	-0.00613
	(0.156)	(0.0417)	(0.0182)	(0.0161)
lsize	0.279	-0.133	-0.0610	-0.00818
	(0.430)	(0.134)	(0.0543)	(0.0476)
lsize2	-0.0340	0.0151	0.00689	0.00317
	(0.0471)	(0.0155)	(0.00635)	(0.00578)
overdraft	0.514*	0.172**	0.0540*	0.0620
	(0.269)	(0.0725)	(0.0307)	(0.0799)
training	0.0866	0.163**	0.0836**	0.102
	(0.240)	(0.0815)	(0.0327)	(0.125)
foreign	-0.973***	0.190	0.146	-0.0312
	(0.294)	(0.358)	(0.169)	(0.522)
internet	-0.0416	0.424***	0.193***	0.197**
	(0.295)	(0.107)	(0.0301)	(0.0838)
neweq	0.116	0.0921	0.0288	-0.0589
	(0.243)	(0.0864)	(0.0394)	(0.0825)
certification	0.0862	0.127	0.0553	0.0960
	(0.348)	(0.0881)	(0.0399)	(0.0992)
export	-0.601**	0.0150	0.0438	0.0473
	(0.269)	(0.0859)	(0.0355)	(0.0604)
highsk	-0.0455	-0.0540	-0.0255	0.0472
	(0.275)	(0.0997)	(0.0427)	(0.119)
lpibpc	-1.247***	-0.380***	-0.115**	-0.111**
	(0.459)	(0.123)	(0.0479)	(0.0463)
lpop	-0.409	0.0113	0.0254	0.0351
	(0.302)	(0.0809)	(0.0303)	(0.0294)
profitability	0.0108	-0.00159	-0.000974	-0.00327
	(0.0309)	(0.0136)	(0.00639)	(0.00572)
multi product			0.0136	
			(0.0306)	
Constant	19.21**	3.047		
	(9.291)	(2.462)		
Observations	1,601	1,601	1,544	1,653
Wald exogeneity	0.0129			
Pseudo R2			0.106	0.0909

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Robust standard errors clustered in the state-sector level are in parentheses.

test.

In order to assure that we are capturing the effect of corruption on production innovation, we deep further on the sensitivity of our results. At first we look if removing the individual value of the firm's answer on the bribe question from the sector-state average calculation would have an effect on the corruption coefficient estimation. This new variable (bribe exo) could be even more exogenous as it measures the sector-state average without taking into account the individual response of the firm, value possibly related to other firm characteristics that would be omitted. The corruption coefficient is marginally smaller, but still strongly significant. Differently, column (2) in Table (5) shows the results when we control for geographical location and propensity to innovate when dealing with access to global markets, as Almeida and Fernandes (2008). We build sector-state measures of the presence of exporters and importers to control if openness have an impact on the probability to introduce new products, with no major change in the results.

Our next series of robustness still concerns geographical location. In column (3) of Table (5) we drop firms from India's biggest cities (Bangalore, Kolkata, Chennai, Delhi, Hyderabad and Mumbai), as being located in these cities could have an effect on product innovation. The main results hold when we estimate with this sample. Moreover, one could argue that there is a self-selection of firms in states with better corruption environment. In that case, more innovative firms would choose to locate at states with lower levels of corruption. At first, note that migration is quite low in India (Munshi and Rosenzweig, 2009; Dollar, Hallward-Driemeier, and Mengistae, 2005). Secondly, as in Dollar, Hallward-Driemeier, and Mengistae (2005), 80% of our firm owners answer that firms are located in that state because the owner was born there. Nonetheless, as it could still exist a self selectivity bias, we follow these authors and we estimate our regression for those firms who are less mobile, which correspond to domestic firms with less than 150 workers. The results in column (4) on table (5) show that there is no such effect, as the bribe coefficient is almost identical to the specification (2) of Table (2).

Our last robustness check tests if the effect of corruption on product innovation holds on a different empirical methdology. We use a standard model where the decision to invest in R&D and the R&D intensity are estimated conjointly, and then product innovation is estimated in a

Table 5: More robustness checks

VARIABLES	(1) dprobit	(2) dprobit	(3) dprobit	(4) dprobit
bribe		-0.00539***	-0.00427***	-0.00534***
		(0.00155)	(0.00150)	(0.00160)
license	0.0531	0.0560	0.139*	0.0524
	(0.0677)	(0.0671)	(0.0776)	(0.0763)
rd	0.157***	0.156***	0.122***	0.145***
	(0.0371)	(0.0372)	(0.0404)	(0.0410)
lage	-0.00433	-0.00150	-0.00947	-0.00757
	(0.0175)	(0.0176)	(0.0183)	(0.0173)
lsize	-0.0793	-0.0816	-0.0540	-0.0881
	(0.0530)	(0.0534)	(0.0600)	(0.0868)
lsize2	0.00915	0.00933	0.00807	0.0107
	(0.00621)	(0.00630)	(0.00705)	(0.0134)
overdraft	0.0548*	0.0597**	0.0567*	0.0657**
	(0.0297)	(0.0297)	(0.0324)	(0.0293)
training	0.0745**	0.0769**	0.0445	0.0807**
	(0.0331)	(0.0333)	(0.0338)	(0.0368)
foreign	0.146	0.166		
	(0.171)	(0.166)		
internet	0.198***	0.197***	0.209***	0.181***
	(0.0294)	(0.0289)	(0.0313)	(0.0296)
neweq	0.0378	0.0380	0.0173	0.0391
	(0.0379)	(0.0380)	(0.0422)	(0.0377)
certification	0.0568	0.0601	0.0797*	0.0645
	(0.0389)	(0.0388)	(0.0445)	(0.0416)
export	0.0400		0.0445	0.0325
	(0.0350)		(0.0408)	(0.0369)
highsk	-0.0230	-0.0234	-0.0489	-0.0193
	(0.0417)	(0.0419)	(0.0429)	(0.0413)
lpibpc	-0.115**	-0.121**	-0.0950*	-0.103**
	(0.0487)	(0.0484)	(0.0507)	(0.0495)
lpop	0.0262	0.0231	0.0606*	0.0314
	(0.0305)	(0.0300)	(0.0323)	(0.0300)
profitability	-0.00132	-0.00143	-0.00184	-0.000798
	(0.00578)	(0.00585)	(0.00718)	(0.00637)
bribe exo	-0.00510***			
	(0.00186)			
di importint		-0.102		
		(0.227)		
di export		0.0905		
		(0.0620)		
Observations	1,601	1,601	1,270	1,411
Pseudo R2	0.107	0.108	0.101	0.0919

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Robust standard errors clustered in the state-sector level are in parentheses.

sequential way[10]. This kind of model is known as the CDM model (Crepon, Duguet, and Mairesse, 1998) and there is empirical evidence on the link between knowledge input and innovation output both for developing countries (Raffo, Lhuillery, and Miotti, 2008) and developed ones (Griffith, Huergo, Mairesse, and Peters, 2006).

We follow Griffith, Huergo, Mairesse, and Peters (2006) and Raffo, Lhuillery, and Miotti (2008) and we estimate the equations:

$$\begin{aligned} R\&Ddummy_i &= 1 \quad if\ RD_i^* = \beta y_i + v_i > 0 \\ R\&Ddummy_i &= 0 \quad if\ RD_i^* = \beta y_i + v_i = 0 \end{aligned} \tag{2}$$

$$\begin{aligned} R\&Dint_i &= \alpha X_i + \epsilon_i \quad if\ R\&Ddummy_i = 1 \\ R\&Dint_i &= 0 \qquad\qquad\ \ if\ R\&Ddummy_i = 0 \end{aligned} \tag{3}$$

$$PRODINNOV_i = \delta R\&Dint_i^* + \eta z_i + v_i \tag{4}$$

Equations (2) and (3) are jointly estimated through a Heckman procedure, with a probit regression for equation (2) and a OLS for equation (3), and we follow Raffo, Lhuillery, and Miotti (2008) on the choice of explanatory variables. The decision to invest in R&D (R&Ddummy) has as explanatory variables y_i: different size dummies to capture firm size, the sector-state corruption level, a domestic and a foreign dummy variable, if the firm has the main operation in the international market and also if receives public funds. The X_i covariates for the R&D intensity equation (R&Dint) are all the same as y_i, unless the size dummies (as R&D intensity is already divided by firm size) and with the addition of a subcontract variable. We then use the predicted R&D intensity (hat rdint) and with other covariates z_i (size dummies, bribe level, domestic and

[10]We do not estimate the third step of this model, as the effect of product innovation on firm productivity is outside the scope of this paper.

foreign dummies) we estimate equation (4) through a probit regression.

Table 6: R&D, R&D intensity and Product Innovation

VARIABLES	(1) RDdummy	(2) RDintensity	(5) Innov
size med	0.366***		0.0591**
	(0.0740)		(0.0300)
size big	0.636***		0.142***
	(0.0924)		(0.0381)
size huge	0.705***		0.234***
	(0.108)		(0.0429)
size enorm	0.865***		0.206***
	(0.115)		(0.0494)
size gigantic	-0.0648		0.0598
	(0.167)		(0.0465)
bribe	-0.00733**	-0.0236*	-0.00358***
	(0.00367)	(0.0122)	(0.00122)
world compet	0.487***	1.520***	
	(0.0885)	(0.342)	
pub funds	0.629*	1.481	
	(0.329)	(1.049)	
domestic	0.381**	0.343	0.0861
	(0.166)	(0.532)	(0.0637)
foreign	-0.220	-0.709	0.194
	(0.340)	(1.413)	(0.143)
subcontract		0.433**	
		(0.200)	
hat rdint			4.96e-12
			(7.43e-12)
Constant	-5.865***	-2.269*	
	(1.922)	(1.336)	
Observations	2,084	2,084	2,041
Pseudo R2			0.0575

* significant at 10%; ** significant at 5%; *** significant at 1%. Sector dummies are included in the estimation.
Note: Robust standard errors are in parentheses.

Results for this approach are shown in Table (6). In column (1) we see that the size of the firm has a significant effect on the decision to invest in R&D, although we do not find effect for firms bigger than 1000 employees. The corruption variable is negative and significant, while the coefficient from participating in the international market is positive and significant, with a similar result for domestic ownership. In column (2), the corruption variable has a negative but marginally significant impact in R&D intensity, whereas the subcontract variable and being in the international market have a positive and significant effect. These results go along with the literature, and here we highlight the negative and significant effect of corruption both in the decision to invest in R&D and in the intensity of doing so.

The estimation of equation (4) gives the results in column (3) where we find that the corruption variable has a significant and negative coefficient on product innovation. The size dummies appear to play a positive and significant role. The predicted value of R&D intensity from the first step has a positive sign but it is not significant, so we do not find evidence for an effect of innovation input on innovation output. We remark that the difference between our results and the ones by Raffo, Lhuillery, and Miotti (2008) and Griffith, Huergo, Mairesse, and Peters (2006) concerns the effect of innovation input on innovation output. Most importantly, the effect of corruption on product innovation holds in this methodology.

5 Concluding Remarks

The main focus of studies on product innovation in developing countries were on production factors, such as technological components, and on firm characteristics, as foreign ownership or export status. Moreover, the relationship between corruption and innovation has been only explored in the macro level. Using a large dataset of Indian firms, in this paper we find that the impact of corruption on product innovation is negative and strongly significant. We show that the effect of sector-state corruption averages on new products is robust for different control variables, cluster size, location of firms and a different empirical methodology. We also test this relationship in an instrumental variable approach and we find similar results, conditional on our identifying strategy and on the exogeneity assumptions. Even though our dataset does not allow for a panel study where the within dimension could be controlled for, our results give strong evidence on the effect of corruption on innovation.

The product dimension of innovation is very important as recent studies show the major weight of the productive structure on macroeconomic growth and development (Hausmann, Hwang, and Rodrik, 2007; Hidalgo, Klinger, Barabási, and Hausmann, 2007). Furthermore, we can stress the main role of innovation directly on productivity and growth (Aghion and Howitt, 1998). Our results can contribute to the elaboration of specific policy recommendations for innovation in developing countries taking into account the negative effect of corruption.

Appendices

A Innovation

Table 7: Innovation by state

innovate?	0	1	total
Punjab	58	30	88
Chandigarh	14	4	18
Haryana	50	55	105
delhi	66	25	91
Rajasthan	87	87	174
Uttar Pradesh	69	97	166
Bihar	28	16	44
West Bengal	107	56	163
Jharkand	160	25	185
Orissa	70	52	122
Madhya Pradesh	88	35	123
Gujarat	102	76	178
Maharashtra	141	53	194
Andhra Pradesh	87	72	159
Karnataka	129	74	203
Kerala	36	30	66
Tamil Nadu	78	109	187
Total	1370	896	2266

Table 8: Innovation by size

		category			
		1	2	3	Total
innovation	0	728	417	130	1,275
	1	351	305	192	848
Total		1,079	722	322	2,123

Table 9: Innovation by sector

innovation	0	1	Total
garments	142	128	270
textiles	126	92	218
drugs and pharm	85	80	165
electronics	59	40	99
electrical appliances	89	66	155
machine tools	115	77	192
auto components	111	105	216
leather and l. products	57	17	74
sugar	3	1	4
food processing	97	58	155
plastics and p. products	82	40	122
rubber and r. products	24	14	38
paper and p. products	18	6	24
structural metals	228	73	301
paints and varnishes	8	12	20
cosmetics and toiletries	7	6	13
other chemicals	63	46	109
mining	3	0	3
mineral processing	19	13	32
marine food processing	4	10	14
agro processing	17	9	26
wood and furniture	13	3	16
Total	1370	896	2,266

B Variable construction for the CDM approach

R&D intensity is the amount spent in R&D divided by the size of the firm. International competition (world compet) measures if the main market of the firm is the international one, while the public fund (pub funds) variable captures if a firm received or not public funds to acquire new technology. We also create a dummy variable that shows if the firm is owned by a domestic company. We add a subcontract variable, capturing if the firm subcontracts research and development projects to other companies or organizations. We build dummy variables for different size categories as Raffo, Lhuillery, and Miotti (2008): a medium size variable (between 20 and 49 employees), big (between 50 and 99), a huge (between 100 and 249), a gigantic (between 250 and 999 employees) and an enormous (more than 1000) variable. At the second step, no variable that has not been presented above enters the estimation.

References

Aghion, P., and P. Howitt (1998): *Endogenous Growth Theory*, vol. 1. MIT Press. 2, 21

Almeida, R., and A. M. Fernandes (2008): "Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys," *The Journal of Development Studies*, 44(5), 701–727. 2, 17

Amin, M. (2009): "Labor regulation and employment in India's retail stores," *Journal of Comparative Economics*, 37(1), 47–61. 2, 10, 11, 14

Anokhin, S., and W. S. Schulze (2009): "Entrepreneurship, innovation, and corruption," *Journal of Business Venturing*, 24(5), 465–476. 3

Banerjee, A. V., and E. Duflo (2005): "Growth Theory through the Lens of Development Economics," in *Handbook of Economic Growth*, ed. by P. Aghion, and S. Durlauf, vol. 1 of *Handbook of Economic Growth*, chap. 7, pp. 473–552. Elsevier. 4

Bardhan, P. (1997): "Corruption and Development: A Review of Issues," *Journal of Economic Literature*, 35(3), 1320–1346. 2

Crepon, B., E. Duguet, and J. Mairesse (1998): "Research, Innovation And Productivity: An Econometric Analysis At The Firm Level," *Economics of Innovation and New Technology*, 7(2), 115–158. 10, 19

De Rosa, D., N. Gooroochurn, and H. Gorg (2010): "Corruption and productivity : firm-level evidence from the BEEPS survey," Policy Research Working Paper Series 5348, The World Bank. 2, 4

Dejardin, M. (2011): "Entrepreneurship and rent-seeking behavior," in *Handbook of Research on Innovation and Entrepreneurship*, ed. by D. Audretsch, O. Falck, S. Heblich, and A. Lederer, chap. 3, pp. 17 – 23. Edward Elgar Publishing. 11

DOLLAR, D., M. HALLWARD-DRIEMEIER, AND T. MENGISTAE (2005): "Investment Climate and Firm Performance in Developing Economies," *Economic Development and Cultural Change*, 54(1), 1–31. 2, 11, 17

EIFERT, B., A. GELB, AND V. RAMACHANDRAN (2005): "Business Environment and Comparative Advantage in Africa: Evidence from the Investment Climate Data," Working Papers 56, Center for Global Development. 4

FISMAN, R., AND J. SVENSSON (2007): "Are corruption and taxation really harmful to growth? Firm level evidence," *Journal of Development Economics*, 83(1), 63–75. 2, 3, 4, 6, 11, 14, 15

GOEDHUYS, M. (2007): "Learning, product innovation, and firm heterogeneity in developing countries; Evidence from Tanzania," *Industrial and Corporate Change*, 16(2), 269–292. 3, 5, 6, 10

GOEDHUYS, M., N. JANZ, J. MAIRESSE, AND P. MOHNEN (2008): "Micro-evidence on innovation and development (MEIDE): an introduction," *European Journal of Development Research*, 20(2), 167–171. 2

GOEDHUYS, M., N. JANZ, AND P. MOHNEN (2008): "What drives productivity in Tanzanian manufacturing firms: technology or business environment?," *European Journal of Development Research*, 20(2), 199–218. 4

GOEDHUYS, M., AND R. VEUGELERS (2008): "Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil," Open access publications from katholieke universiteit leuven, Katholieke Universiteit Leuven. 2, 3, 6

GRIFFITH, R., E. HUERGO, J. MAIRESSE, AND B. PETERS (2006): "Innovation and Productivity Across Four European Countries," *Oxford Review of Economic Policy*, 22(4), 483–498. 10, 19, 21

HAUSMANN, R., J. HWANG, AND D. RODRIK (2007): "What you export matters," *Journal of Economic Growth*, 12(1), 1–25. 21

HESTON, A., AND V. KUMAR (2008): "Institutional Flaws and Corruption Incentives in India," *The Journal of Development Studies*, 44(9), 1243–1261. 3

HIDALGO, C. A., B. KLINGER, A.-L. BARABÁSI, AND R. HAUSMANN (2007): "The Product Space Conditions the Development of Nations," *Science*, 317(5837), 482–487. 21

KLINGER, B., AND D. LEDERMAN (2006): "Diversification, innovation, and imitation inside the Global Technological Frontier," Policy Research Working Paper Series 3872, The World Bank. 13

KRUEGER, A. O. (1974): "The Political Economy of the Rent-Seeking Society," *The American Economic Review*, 64(3), 291–303. 2

LEDERMAN, D. (2010): "An international multilevel analysis of product innovation," *Journal of International Business Studies*, 41(4), 606–619. 2, 3, 6, 10

MAIRESSE, J., AND P. MOHNEN (2010): "Using Innovations Surveys for Econometric Analysis," NBER Working Papers 15857, National Bureau of Economic Research, Inc. 2, 5

MOULTON, B. R. (1990): "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units," *The Review of Economics and Statistics*, 72(2), 334–338. 11

Munshi, K., and M. Rosenzweig (2009): "Why is Mobility in India so Low? Social Insurance, Inequality, and Growth," NBER Working Papers 14850, National Bureau of Economic Research, Inc. 17

Murphy, K. M., A. Shleifer, and R. W. Vishny (1993): "Why Is Rent-Seeking So Costly to Growth?," *American Economic Review*, 83(2), 409–14. 11

OECD (2005): *Oslo Manual*. 3rd edition. Paris; OECD. 5

Porter, M. E., and C. van der Linde (1995): "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives*, 9(4), 97–118. 14

Raffo, J., S. Lhuillery, and L. Miotti (2008): "Northern and southern innovativity: a comparison across European and Latin American countries," *European Journal of Development Research*, 20(2), 219–239. 10, 19, 21, 25